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WASTE MANAGEMENT FACILITY ACCIDENT ANALYSIS (WASTE_ACC) SYSTEM: SOFTWARE FOR ANALYSIS OF WASTE MANAGEMENT ALTERNATIVES*

by
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ABSTRACT

This paper describes the Waste Management Facility Accident Analysis (WASTE_ACC) software, which was developed at Argonne National Laboratory (ANL) to support the U.S. Department of Energy's (DOE's) Waste Management (WM) Programmatic Environmental Impact Statement (PEIS). WASTE_ACC is a decision support and database system that is compatible with Microsoft® Windows™. It assesses potential atmospheric releases from accidents at waste management facilities. The software provides the user with an easy-to-use tool to determine the risk-dominant accident sequences for the many possible combinations of process technologies, waste and facility types, and alternative cases described in the WM PEIS. In addition, its structure will allow additional alternative cases and assumptions to be tested as part of the future DOE programmatic decision-making process. The WASTE_ACC system demonstrates one approach to performing a generic, systemwide evaluation of accident risks at waste management facilities. The advantages of WASTE_ACC are threefold. First, the software gets waste volume and radiological profile data that were used to perform other WM PEIS-related analyses directly from the WASTE_MGMT system. Second, the system allows for a consistent analysis across all sites and waste streams, which enables decision makers to understand more fully the trade-offs among various policy options and scenarios. Third, the system is easy to operate; even complex scenario runs are completed within minutes.

INTRODUCTION

This paper builds on earlier work that developed the computational framework for identifying risk-dominant accident sequences (Refs. 1 and 2). Only atmospheric releases are considered, and risk is assessed in terms of the airborne source terms, measured in Ci, along with the frequency of the associated accident sequence. The framework employs a probabilistic analysis for potential radiological accidents at DOE facilities that manage low-level waste (LLW), low-level mixed waste (LLMW), transuranic waste (TRUW), and high-level waste (HLW). The framework considers both waste storage and waste treatment, as well as treatment technology options including incineration, vitrification, and wet-air oxidation. In addition, it considers internally initiated industrial-type accidents that may occur during waste management activities (e.g., breaching a waste drum during handling and rendering a portion of the contents airborne) and externally initiated accidents (e.g., earthquakes or airplane strikes). The WASTE_ACC system implements this framework to provide policy analysts and researchers with an easy-to-use tool.

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The WASTE_ACC system generates a consistent evaluation of accident risks across all 52 potential waste management sites within the purview of the WM PEIS and across the various waste streams (i.e., LLW, LLMW, HLW, and TRUW). Many of the input and process parameters used by WASTE_ACC were developed specifically for the WM PEIS, and these data reside in comprehensive generic databases that are an integral part of the WASTE_ACC system. The WASTE_ACC software uses a state-of-the-art database that incorporates the latest accident information from DOE safety documents. To date, no other system can provide the consistent analysis across sites and waste streams required in the WM PEIS. Furthermore, no other model utilizes site-specific waste volumes and radiological profiles, as developed through ANL's WASTE_MGMT system.

Although WASTE_ACC was developed to support the WM PEIS, any site contemplating processing radioactively contaminated waste could use the system to obtain at least a first-cut analysis. All that would be required to perform site-specific analyses is further development of supplemental site-specific databases. Besides being used for waste treatment facilities, WASTE_ACC's probabilistic approach could be used for other types of facilities, such as hazardous waste incinerators or chemical processing plants, and for other types of facility accidents.

WASTE_ACC CAPABILITIES

WASTE_ACC can be used to:

- Determine the risk-dominant accident sequence as a function of treatment site, waste management alternative, and waste type;
- Perform preliminary calculations of the health effects of the postulated accident sequence for four receptors: off-site maximally exposed individual (MEI), off-site population, on-site MEI, and on-site population;
- Develop the progression of accident sequences for external initiators (such as seismic events or airplane crashes) and calculate the probabilities of accident progression along various event tree branches;
- Print records associated with the risk-dominant accident sequences to standard or laser printers; and
- Generate ASCII text output files containing airborne release data by nuclide for risk-dominant accident sequences.

The sections below describe the WASTE_ACC software.

WASTE_ACC DEVELOPMENT

The programming challenge was to construct an easy-to-use PC-based system with the capacity to process large amounts of data and the flexibility to accommodate various waste management alternatives, waste streams, and site-specific information. The solution implemented an application shell (based on the Microsoft FoxPro for Windows database system) around the framework that had been developed earlier. This solution has two main advantages. First, FoxPro provided the software tools necessary to develop a Windows-compatible graphical user interface, thereby enabling a user to manipulate the model by mease of a familiar metaphor. Second, the development of an application shell around the framework integrated several stand-alone modules that previously constituted the accident analysis system into a single application. The system can now be run from a single screen with a few mouse clicks, and run-time has been reduced by more than 75%.

WASTE_ACC REQUIREMENTS

The system requires a DOS-compatible computer running Microsoft Windows 3.1, a microprocessor equivalent to a 33 MHz 486SX or greater, and at least 4 MB of RAM. The software itself requires about 2 MB of disk space for installation (beyond that required for FoxPro). The WASTE_MGMT input data files can take up to 500 MB for all alternatives and waste types. Furthermore, the system can require as much as 300 MB of additional free disk space to run. Scenario runs generally take between 1 and 10 minutes on a PC powered by a 90-MHz Pentium, depending on the waste type and the complexity of the alternative being considered. Decentralized cases require more computational time and disk space than centralized alternatives because they have more sites to be analyzed. LLMW alternatives require longer execution times because they have more waste subtypes.

WASTE_ACC OPERATION

Fig. 1 presents WASTE_ACC's welcome screen. After clicking on the Continue button, the system's main screen appears, as presented in Fig. 2. These screens illustrate the latest improved user interface. Buttons, list boxes, and text fields are conveniently and logically arranged on the screen. These input mechanisms address the information requirements for running an alternative clearly and in the English language. All information is requested *before* a model run begins. In contrast, earlier versions used menus that popped up on the screen while the program was running. These menus required the user to have considerable knowledge of the executing module to select the correct option.

Besides the user interface, the model's structure has also been updated. The updated version of WASTE_ACC integrates numerous stand-alone modules into a single application that runs to completion at the click of a button. Stand-alone modules had been necessary to cope with the extremely large data files and complex data manipulation steps inherent in the model. However, improved computer resources and streamlined code enabled the system to be integrated into a single application. The integration greatly reduced processing turn-around time and improved the system's integrity and reliability. A run that used to require four separate programs and some human intervention can now be completed with a few mouse clicks in a fraction of the time. The next few paragraphs describe the main screen in more detail, and discuss how to run WASTE_ACC.

User Input

The screen displayed in Fig. 2 is divided roughly into three parts — top, middle, and bottom. In the top part of the screen, the user selects which waste stream and alternative to run and the desired output options. The middle of the screen contains an area that displays which module is running so the user can monitor a run's progress. It also contains buttons to start model execution or to exit the program. A check box labeled "Batch" enables the user to set up a series of runs all at once. In the bottom part of the screen, users can tell WASTE_ACC where to find input files and where to locate working (scratch) disk space. The top part is described first.

In the first field, under the phrase "Waste Stream:," the user can select a waste

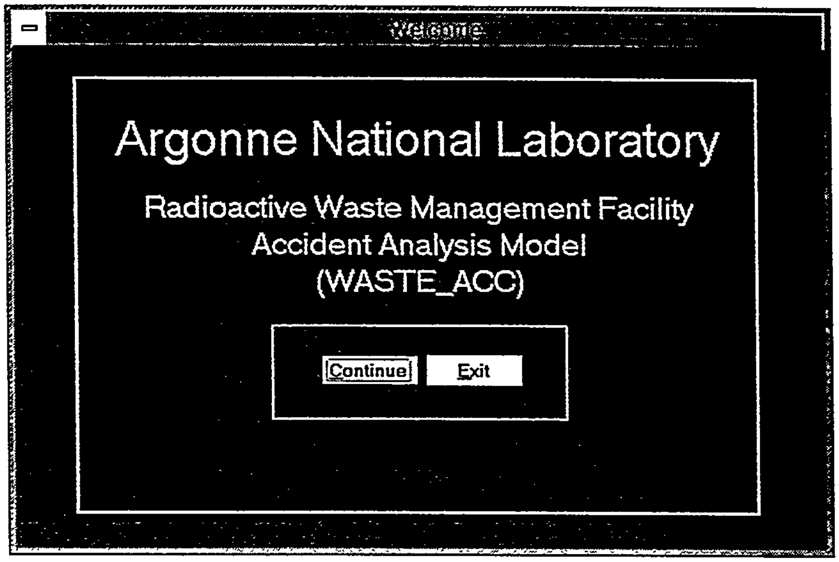


Fig. 1 WASTE_ACC Welcome Screen

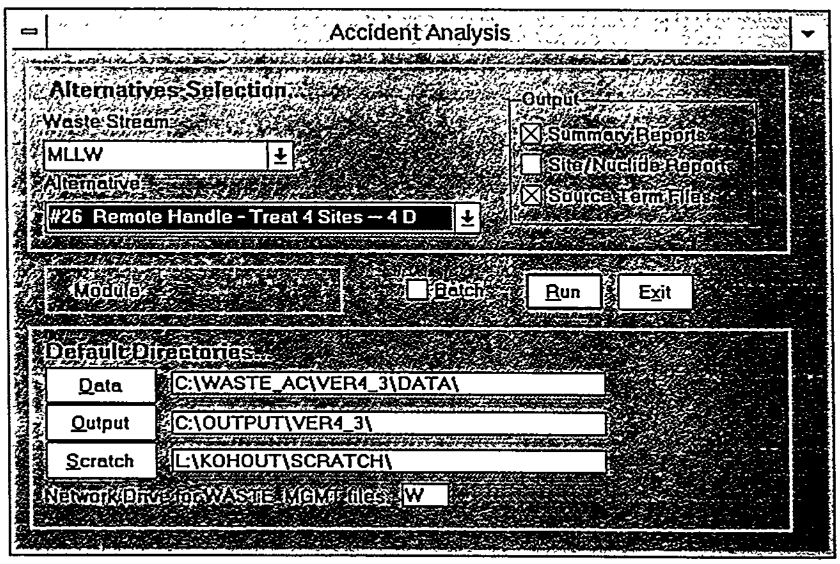


Fig. 2 WASTE_ACC Main Screen

stream to be analyzed from a list box. This box provides a complete list of the possible choices, from which the user selects one. The waste stream choices are: High Level Waste, Low Level Waste, ER Low Level Waste, Low Level Mixed Waste, ER Low Level Mixed Waste, Transuranic Waste, and ER Transuranic Waste. In the field below, labeled "Alternative:," the user selects from another list box containing the possible alternatives for the selected waste stream.

After the alternative has been selected, the user can choose output options. Regardless of the options selected, WASTE_ACC always produces a summary data file that is sent to the output directory. If the "Summary Reports" check box is selected, as it is in Fig. 2, the system sends a formatted summary report to the printer and to the screen, as shown in Fig. 3. If the "Site/Nuclide Reports" check box is selected, the program prints reports that detail source terms by site and nuclide for each risk-dominant accident sequence. Finally, if the "Source Term Files" check box is selected, a source terms data file is sent to the output directory.

The user provides file location information by clicking on the appropriate button in the lower part of the screen. When the user clicks on the "Data" button, a standard Windows file-open dialog box appears. The user selects a directory to tell WASTE_ACC where to find various support and input files, except for the WASTE_MGMT data (as of Version 4.3 in October 1995). Similarly, by clicking on the "Output" button, the user can tell the program where to put the output files. Files can be directed to any available drive, and not all the drives need to be the same. The user can select the "Scratch" or temporary drive, where temporary files will be placed. In most cases, this should be the user's own hard drive to minimize network traffic and increase processing speed, but the extremely large capacity needed to run the model (more than 300 MB free space) may prevent this. As an added feature, the user does not have to select a button to specify a drive but may instead type the directory name directly into the field. Finally, the user tells the system where to find the WASTE_MGMT files by typing a drive letter next to the phrase "Network Drive for WASTE_MGMT files:". This drive may be the user's own hard drive (i.e., C), but because the size of the WASTE_MGMT files needed by WASTE_ACC is so large (more than 500 MB), the drive is most likely to be that of a file server.

Performing Scenario Runs

WASTE_ACC can perform runs one at a time, sequentially, or grouped together in a batch. To run a single alternative, the user simply makes the appropriate waste stream, alternative, and directory choices and then clicks on the "Run" button. As the model runs, small message windows appear on the screen to indicate WASTE_ACC's progress. Besides messages, WASTE_ACC displays the name of the executing module in the main screen next to the word "Module:" to tell the user exactly which stage the model is executing. Then, when an alternative has finished processing, WASTE_ACC alerts the user with a beep and a message. The user has the option to either quit the program or make additional (sequential) model runs.

When several alternatives must be run, the user may elect to group them together in a "batch" run to significantly reduce processing time. To initiate a batch run, the user clicks on the "Batch" check box, and a screen similar to that shown in Fig. 4 appears. The user chooses which alternatives to run by typing a "T" in the "T/F" (last) column of the screen. Then, when the model runs, WASTE_ACC processes all of the designated alternatives and places the resulting source term files in the output directory as specified on the main screen.

Report

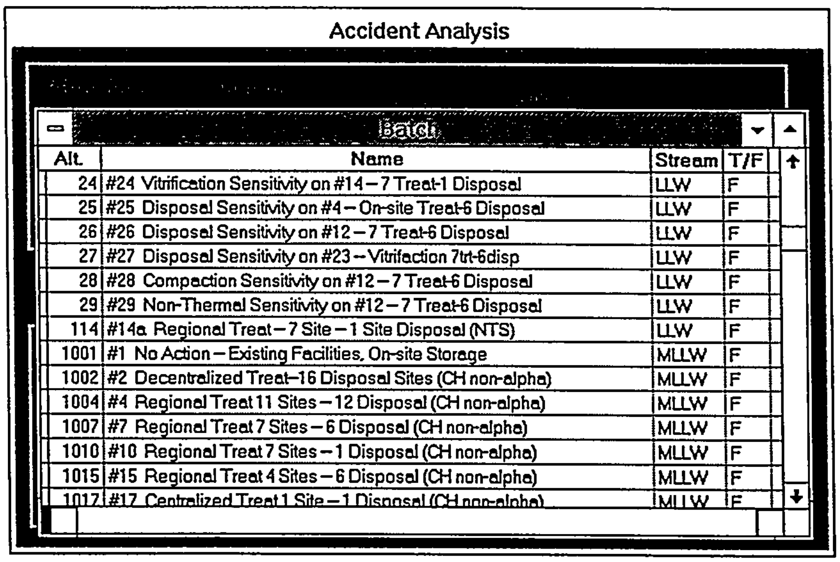
Press any key to continue...

Low Level Mixed Waste: Case 26

Function: q-INCINERATION

						Maximally Exposed Individual - Offsite					Public Offsite	
Site	Init	VMAR (m3)	MAR (Ci)	TRF	Source Term (Ci)	Dose (rem)	Cancer Probability	Risk (rem/yr)	Frequency (/yr)	Frequency Class	Dose (person-rem)	Cancer Fatalities
HANF	IEX1	6.5E-05	9.9E-03	8.4E-06	8.4E-08	2.7E-09	0.0E+00	4.1E-11	1.5E-02	I	8.8E-05	4.4E-08
HANF	EQ4	6.5E-05	9.9E-03	3.1E-04	3.1E-06	1.0E-07	1.0E-10	2.5E-12	2.5E-05	III	3.3E-03	1.7E-06
HANF	IFF1	6.5E-05	9.9E-03	1.8E-06	1.8E-08	5.8E-10	0.0E+00	5.8E-13	1.0E-03	II	1.9E-05	9.5E-09
INEL	IEX1	1.9E-01	1.8E+01	8.4E-06	1.6E-04	7.8E-08	0.0E+00	1.2E-09	1.5E-02	I	9.5E-04	4.8E-07
INEL	EQ4	1.9E-01	1.8E+01	3.1E-04	5.8E-03	2.9E-06	1.5E-09	7.3E-11	2.5E-05	III	3.6E-02	1.8E-05
INEL	IFF1	1.9E-01	1.8E+01	1.8E-06	3.3E-05	1.7E-08	0.0E+00	1.7E-11	1.0E-03	II	2.0E-04	1.0E-07
ORNL	IEX1	1.1E-02	3.0E+00	8.4E-06	2.6E-05	5.4E-07	3.0E-10	8.2E-09	1.5E-02	I	1.6E-02	8.2E-06
ORNL	EQ4	1.1E-02	3.0E+00	3.1E-04	9.6E-04	2.0E-05	1.0E-08	5.1E-10	2.5E-05	III	6.2E-01	3.1E-04
ORNL	IFF1	1.1E-02	3.0E+00	1.8E-06	5.5E-06	1.2E-07	1.0E-10	1.2E-10	1.0E-03	II	3.5E-03	1.8E-06
SRS	IEX1	1.4E-03	1.4E-01	8.4E-06	1.1E-06	1.6E-09	0.0E+00	2.4E-11	1.5E-02	I	7.2E-05	3.6E-08
SRS	EQ4	1.4E-03	1.4E-01	3.1E-04	4.3E-05	6.0E-08	0.0E+00	1.5E-12	2.5E-05	III	2.7E-03	1.3E-06
SRS	IFF1	1.4E-03	1.4E-01	1.8E-06	2.5E-07	3.4E-10	0.0E+00	3.4E-13	1.0E-03	II	1.5E-05	7.7E-09

Fig. 3 Sample WASTE_ACC Summary Report Screen



Accident Analysis

Batch

Alt.	Name	Stream	T/F
24	#24 Vitrification Sensitivity on #14 – 7 Treat-1 Disposal	LLW	F
25	#25 Disposal Sensitivity on #4 – On-site Treat-6 Disposal	LLW	F
26	#26 Disposal Sensitivity on #12 – 7 Treat-6 Disposal	LLW	F
27	#27 Disposal Sensitivity on #23 – Vitrifaction 7trt-6disp	LLW	F
28	#28 Compaction Sensitivity on #12 – 7 Treat-6 Disposal	LLW	F
29	#29 Non-Thermal Sensitivity on #12 – 7 Treat-6 Disposal	LLW	F
114	#14a Regional Treat – 7 Site – 1 Site Disposal (NTS)	LLW	F
1001	#1 No Action – Existing Facilities, On-site Storage	MLLW	F
1002	#2 Decentralized Treat–16 Disposal Sites (CH non-alpha)	MLLW	F
1004	#4 Regional Treat 11 Sites – 12 Disposal (CH non-alpha)	MLLW	F
1007	#7 Regional Treat 7 Sites – 6 Disposal (CH non-alpha)	MLLW	F
1010	#10 Regional Treat 7 Sites – 1 Disposal (CH non-alpha)	MLLW	F
1015	#15 Regional Treat 4 Sites – 6 Disposal (CH non-alpha)	MLLW	F
1017	#17 Centralized Treat 1 Site – 1 Disposal (CH non-alpha)	MLLW	F

Fig. 4 Alternatives Selection for Batch Runs

After the user has clicked on the Run button, WASTE_ACC sets up the work space, which in this context means it closes any files that may be open from earlier model runs. Next, the system locates necessary input files for the waste stream of the scenario being processed. When all the files are located, the computations begin. First, the quantity and characteristics of the material at risk (MAR) are calculated. After the MAR file is built, the system assigns unit dose conversion factors (DCFs), provided by Oak Ridge National Laboratory, to the MAR on the basis of its characteristics. Next, the system develops the accident parameters (such as accident frequency, damage fraction, and conditional probability) for each site, accident initiator, and sequence. These accident parameters are then linked to the MAR, and the model computes releases, doses, risks, and consequences for all of the accident sequences. Finally, the system ranks accident sequences by risk and then constructs a file to contain radiological source terms for sequences with the largest impacts. The system writes this file to the output directory, and the computations are complete.

If the model is processing a single run, the system displays the results in a series of report screens (see Fig. 3). After all of the results have been presented, the application returns to the main screen so the user can choose the next action. For batch runs, the system does not present results on the screen since this would interrupt the program's operation. Instead, as the program loops though each of the designated alternatives, it writes the results to the output file described above. When all of the alternatives are done, the main screen appears, and the user regains control.

Output

The final outputs of WASTE_ACC are site-specific atmospheric source term results and accident summaries. One type of source term result is on the amount of radioactivity released to the atmosphere per radionuclide of each accident initiator's risk-dominant sequence. The accident summaries (partially shown in Fig. 3) provide detailed information about the risk-dominant accidents, summed over all radionuclides released, which include data on the:

- Volume of material at risk (m^3),
- Material at risk (Ci),
- Air-release source term (Ci),
- Dose to the off-site MEI (person-rem),
- Cancer risk of the off-site MEI (incidents/yr),
- Risk to the off-site MEI (rem/yr),
- Doses to off-site population (person-rem),
- Number of excess latent cancer fatalities in the off-site population,
- Accident frequency (incidents/yr), and
- Frequency class.

FUTURE DEVELOPMENT

Although WASTE_ACC has come a long way toward becoming an easy system to use, much work remains. The system focuses primarily on DOE Waste Management issues and capabilities, but with some data development, it could perform accident analyses for other systems, such as hazardous waste incinerators or chemical processing plants. Moreover, the large and complex databases that support WASTE_ACC could have tools, such as input screens and preprocessing routines, that would make data collection and entry easier and less error-prone. The system could be adapted to perform detailed analyses on sites by using even more site-specific data than are available or appropriate for a nationwide analysis. Finally, the system could be adapted to quantify the uncertainty for the computed risk values. The model would account for uncertainties in the input data and process parameters, so instead of computing a point estimate, the model would produce a probability distribution reflecting the uncertainty of the system.

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